

FOOD DELIVERY AS A CONDITIONAL STIMULUS: FEATURE-LEARNING AND MEMORY IN PIGEONS¹

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Three experiments investigated the learning and memory of discriminations based on presence versus absence of a pre-trial food delivery. In Experiment 1 half the illuminations of a response key were followed by food regardless of the subject's behavior. In one group an extra food delivery preceded only reinforced trials (feature-positive condition), whereas in a second group it preceded only nonreinforced trials (feature-negative condition). Key pecks and approaches revealed more rapid and superior discrimination learning in the first group. Experiment 2 replicated the results of Experiment 1 but yielded no evidence that greater "unexpectedness" of pretrial food conditions facilitates discriminative performance. In Experiment 3, individual pigeons trained on a conditional discrimination exhibited a within-subject feature-positive superiority. Delay between pretrial and trial stimuli interacted with feature-positive versus feature-negative training in both the between-group (Experiment 2) and within-subject (Experiment 3) procedures: performance was decremented at both short and long delays in the feature-positive condition but was decremented only at longer delays in the feature-negative condition. The feature-positive superiority obtained here is incompatible with explanations based on either the general concept of "perceptual organization" or on the conditional nature of feature-negative discriminations.

Key words: autoshaping, go-no go discrimination, conditional discrimination, feature-positive effect, short-term retention, surprise, approach behavior, key peck, pigeons

In 1969, Jenkins and Sainsbury described an asymmetry in the learning of what appeared to be a pair of symmetrical discriminations: when a feature unique to only one of two stimulus displays was always associated with reinforcement, discrimination learning was faster and better than when the same feature was always associated with nonreinforcement. For example, Jenkins and Sainsbury (1969, 1970) trained pigeons on a successive operant discrimination in which two stimulus displays were distinguished by the presence or absence of a single unique feature. One display contained three dots; the other display contained a star in place of the third dot. Thus, the star served as a distinctive feature, whereas the dots were elements common to both displays. Feature-positive training, in which the feature was

a reliable signal for reinforcement, yielded extremely rapid discrimination learning. However, feature-negative training, in which the feature served as a reliable signal for nonreinforcement, yielded negligible discriminative performance in almost every subject.

The feature-positive effect appears to be a fairly general finding in both the animal and human literature (see Hearst, 1978). One apparent example of a feature-positive superiority was provided by a 1975 experiment of Terry and Wagner, who used rabbits in an eyelid conditioning paradigm. Their basic design, which was originally discussed by Pavlov (1927, pp. 123-124) and later by Konorski and Laskowski (1959), can be conceptualized as involving feature-positive versus feature-negative training in different subgroups, with an aversive pretrial US serving as the feature; i.e., a pretrial US (feature) was presented before half the occurrences of a CS (common element), and signaled whether or not the same US would follow the CS. Subjects for whom a pretrial US signaled another (posttrial) US presentation exhibited better discriminative performance than subjects for whom a pretrial US signaled the absence of a posttrial US. Thus, Terry and

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Wagner's data indicated a feature-positive superiority even though common and distinctive features were presented sequentially (see Hearst, 1978). However, they were not explicitly concerned with this aspect of their experiment and, instead, were interested primarily in assessing differences in short-term retention of pretrial USs which were either expected or unexpected by the subject. They found significantly better short-term retention of USs that were unexpected, or "surprising," to the subject, compared to USs that were expected (see below, Experiment 2). They ascribed this difference to systematic variation in rehearsal of pretrial USs, based on the assumption that surprising events elicit more rehearsal than do expected ones.

The investigations reported here represent our analysis of a feature-positive effect obtained in a classical conditioning situation (autoshaping) different from that employed by Terry and Wagner (1975); however, the basic design was otherwise very similar to theirs. We also report the effects of manipulating the degree of expectancy of pretrial USs, and of varying the delay interval between pretrial and trial stimuli.

EXPERIMENT 1

In order to see whether we could reliably establish a feature-positive effect in a situation analogous to Terry and Wagner's, we performed an appetitive counterpart to their experiment. As indicated above, their pretrial US involved the simple presence or absence of an aversive stimulus to distinguish reinforced from nonreinforced trials. Besides the appetitive nature of the task, our design differed from theirs in that a common stimulus was presented before every trial, in addition to a feature stimulus which was presented before half the trials. We included the presentation of a common stimulus, a clicker, on all trials because we were afraid that, on Terry and Wagner's type of procedure, the mere presentation of a pretrial stimulus might have had some "ready signal" value, facilitating behavior on the following trial and thus biasing the results in favor of a feature-positive effect.

METHOD

Subjects

Twelve experimentally naive female White

Carneau pigeons, maintained at 75% of their free-feeding body weights, served. Birds were housed individually in a constantly illuminated room; water was always available.

Apparatus

Two three-key Lehigh Valley conditioning chambers were equipped with specially constructed left-right tilt floors (see Wasserman, Franklin, & Hearst, 1974) which enabled us to monitor approach behavior to the two side keys. The keys were situated 24 cm above the tilt floor, and a houselight was located over the center key, 31 cm above floor level. A magazine aperture, 11 cm above floor level, was illuminated with white light during the 3-sec periods when grain was available. In addition, each chamber was equipped with an 8-ohm loudspeaker, 25 mm in diameter (Calectro S2-214), mounted in a small metal box (Bud CU-3000A), which was fastened to the in-line read-out projector (I.E.E. B061 with G.E. 44 lamps) behind the center key. A Foringer click generator (1166-4-MI) was calibrated to produce a clicking sound with a frequency of approximately 25 pips per second, and an amplitude of approximately 88 dB (measured in front of the center key with Brüel & Kjaer sound level meter). The background noise level in the box was approximately 84 dB.

Procedure

All birds were given two consecutive days of magazine training. On the first day, the experimenter held the subject's head in the lighted magazine aperture and allowed it to eat for 5 to 10 sec. The bird was then given five 10-sec food presentations, followed by the presentation of 30 3-sec reinforcements separated by variable intervals averaging 30 sec. On the second day, all birds were placed in the chambers and received approximately 15 3-sec reinforcements separated by variable intervals averaging 30 sec.

After completion of magazine training, all birds were assigned randomly to one of two groups, either Feature Positive (FP) or Feature Negative (FN). Discrimination training for both groups began on the next day. For all subjects, each trial included a 6-sec illumination of either the left or right key with a white vertical line on a black background. Left and right key illuminations were presented according to a random sequence and were separated

by an intertrial interval averaging 90 sec (range = 45 to 135 sec). Each trial was preceded by a 6-sec preparatory interval: on nonfeature (\bar{F}) trials, the first 3 sec of this interval included the presentation of the clicker stimulus alone; on feature (F) trials, the first 3 sec of this interval included the presentation of a compound stimulus consisting of the clicker plus a simultaneous grain presentation. On both F and \bar{F} trials, the latter part of this preparatory interval consisted of a 3-sec delay period during which no external stimuli were presented. In the FP condition, key illuminations preceded by food (F trials) were always followed by reinforcement, and key illuminations preceded by the clicker only (\bar{F} trials) were never followed by reinforcement (see Figure 1). These contingencies were reversed in the FN condition: \bar{F} trials were always followed by reinforcement, and F trials were never followed by reinforcement. Reinforcement consisted of a 3-sec post-trial grain presentation identical to the pre-trial food delivery. A classical conditioning (autoshaping) procedure was used, such that reinforcement presentations were never affected by subjects' responding. Thus, in our situation, the presentation of a pre-trial food delivery served as a unique feature distinguishing the two types of trials, and the clicker and keylight stimuli were common to all trials. In the FP condition, F trials were always positive and \bar{F} trials were always negative, whereas in the FN group, F trials were always negative, and \bar{F} trials always positive.

Throughout discrimination training, all sessions consisted of 24 trials (12 F and 12 \bar{F}), and the houselight was constantly illuminated for the duration of each session. The first trial of

every session was always positive, and trial presentations were balanced for first-order sequential probabilities according to sequences given in Vandament, Burright, Fessenden, and Barker (1970). Subjects in each group were tested for 20 days under their respective procedures. All subjects received 24 3-sec grain presentations per session (i.e., half before and half after trials) and, to maintain their weights at the 75% value, were fed a supplementary ration of grain approximately 45 min after the end of their daily session.

RESULTS AND DISCUSSION

The two main dependent measures were the number of pecks made to the illuminated left and right keys during both F and \bar{F} trials, and the amount of time spent on the same side of the chamber as the illuminated key during F and \bar{F} trials. This latter measure was translated into an index of performance which we refer to as an approach-withdrawal ratio (see Wasserman et al., 1974). The amount of trial time that each subject spent on the same side of the chamber as an illuminated key during each session was divided by the total amount of time that a keylight was present. Ratios greater than .5 indicate approach behavior, whereas ratios less than .5 indicate withdrawal from an illuminated key.

The data from the key peck measure are plotted in Figure 2 as the proportion of responding on positive trials relative to total responding on all trials. Key peck data from two birds—one from each group—had to be eliminated because these subjects almost never pecked the illuminated key. Both groups responded approximately equally on F and \bar{F}

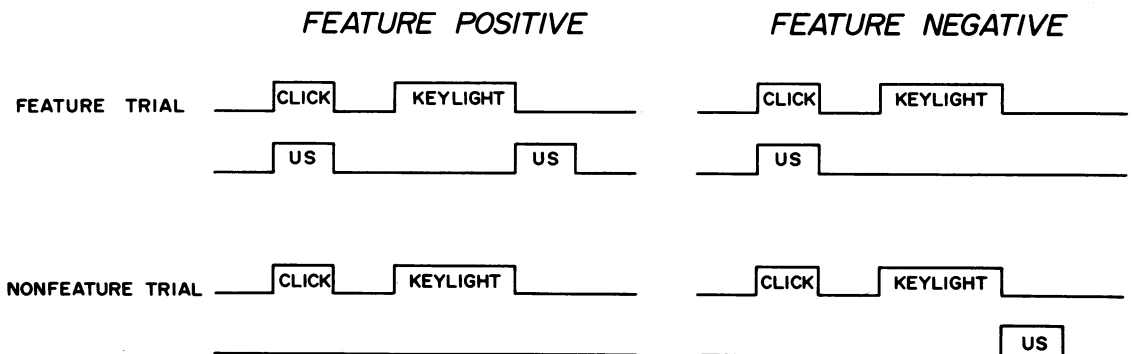


Fig. 1. Schematic representation of Feature Positive (FP) and Feature Negative (FN) conditions. Feature (F) trials, including a pre-trial food delivery, were reinforced in FP group, and nonfeature (\bar{F}) trials, preceded by clicker stimulus only, were not; these contingencies were reversed in FN group. See text for further explanation.

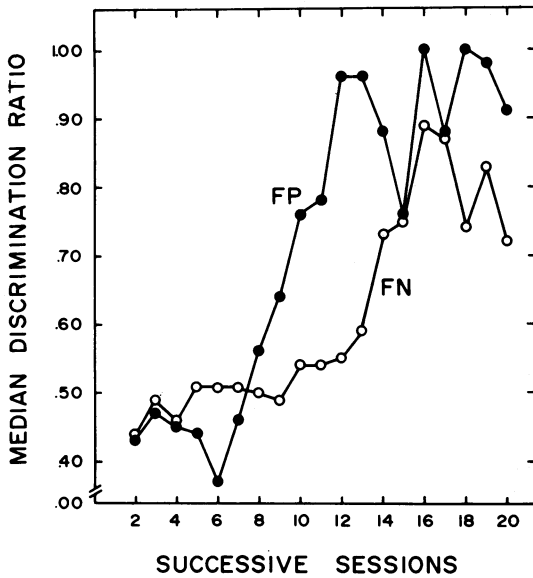


Fig. 2. Median proportion of key pecks on positive trials relative to total key pecks on all trials for FP and FN groups of Experiment 1.

trials over the first several days of training, although there appeared to be some tendency for birds in the FP group to respond more on negative (\bar{F}) trials. The FP group, however, soon showed a rapid increase in the proportion of responding on positive trials, even though this group had shown a tendency to respond less on positive trials prior to this increase. The FN group exhibited much slower improvement in discriminative performance, and, although the curves for the two groups converged toward a ceiling at the end of training, the FN group evidenced a lower level of performance throughout. The mean number of days required for subjects in the FP group to reach a discrimination ratio of .85 in a single session was 10.4 (range = 7 to 14). Two birds in the FN group never reached this level of performance and were assigned a value of 20 days; the mean number of days required to reach a discrimination ratio of .85 in a single session in the FN group was 16.8 (range = 14 to 20). A *t* test revealed that this difference was reliable, $t(8) = 3.33$, $p < .02$.

Approach-withdrawal data for both F and \bar{F} trials are plotted for each group in Figure 3. As described previously, this measure represents the proportion of total trial time that subjects spent on the same side of the chamber as an illuminated key. Therefore, a ratio of 1.00 would indicate maximal approach to the

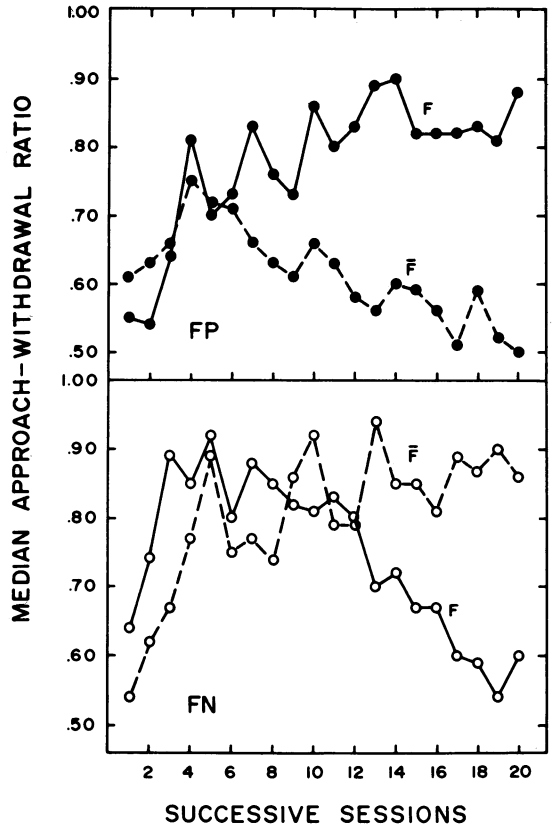


Fig. 3. Median approach-withdrawal ratios on positive and negative trials for FP (upper panel) and FN (lower panel) groups of Experiment 1. F = feature trials; \bar{F} = nonfeature trials. See text for further explanation.

lighted key, whereas a ratio of 0.00 would indicate maximal withdrawal. The FP group exhibited a steady increase in approach behavior on both types of trials over the first four days of discrimination training, after which the level of approach behavior decreased approximately to a chance level (.50) on negative (\bar{F}) trials but continued to increase somewhat on positive (F) trials. The FN group also demonstrated a steady increase in approach behavior on both kinds of trials over the first few days of training, but approach to the illuminated key on negative (F) trials remained at a relatively high level for several days, and consistent differentiation between F and \bar{F} trials was not obtained until Day 13.

The amount of approach behavior obtained on negative trials was subtracted from that obtained on positive trials for each individual subject throughout all sessions of discrimination training. When this difference score was

greater than +.20 on two consecutive days, a subject was said to have met criterion. The mean number of days required to reach criterion was 11.3 (range = 7 to 15) in the FP group, and 15.3 (range = 9 to 20) in the FN group. This difference was only marginally significant, $t(10) = 2.01$, $p = .08$. However, t tests for related measures performed on the median approach-withdrawal ratios over Days 10 to 14 of discrimination training yielded a significant difference between F and \bar{F} trials in the FP group, $t(5) = 5.37$, $p < .01$, but not in the FN group, $t < 1$.

The results of this first experiment provided evidence for a feature-positive superiority in a novel situation—one involving a discrimination based on memory of prior stimulus conditions. This result is similar to a previous finding from our laboratory reported by Wolff and Hearst (see Hearst, 1978), who also demonstrated a "sequential" feature-positive superiority. In their experiment, a green keylight served as the feature, which was presented directly before the element common to all trials—a white keylight. Our procedure differs primarily from the one employed by Wolff and Hearst, and from the one employed by Jenkins and Sainsbury (1969, 1970) in that a US served as the feature. We also found, as did Wolff and Hearst, that subjects in both feature-positive and feature-negative conditions ultimately exhibited good discriminative performance, whereas almost none of Jenkins and Sainsbury's feature-negative subjects ever exceeded chance performance.

EXPERIMENT 2

In our next experiment, we attempted to provide additional evidence for a feature-positive superiority in this situation, and to examine some characteristics of memory-processing in pigeons. This latter effort consisted of (a) attempting to manipulate short-term retention of pretrial events in a manner similar to that reported by Terry and Wagner (1975) in their "surprise" experiments, and (b) investigating the effect of varying the delay between the preparatory interval and the onset of the keylight stimulus.

As mentioned previously, Terry and Wagner found better short-term retention of pretrial USs which were unexpected, or "surprising," to the subject, compared to pretrial USs which were expected. Their procedure involved the

establishment of a simple CS+ versus CS- discrimination during initial training, followed by differential training based on presence vs. absence of pretrial USs (as described above), the same US being used throughout the experiment. During a subsequent test phase, CS+ and CS- were presented directly before the pretrial US. Pretrial USs preceded by CS+ were said to be expected and engendered worse discriminative performance than pretrial USs preceded by CS-, which were said to be surprising. We attempted to extend their findings by assessing memory of a "US" representation, as well as of a US representation. That is, the presentation of a CS- may reinstate an internal representation which we may refer to as "US". Presumably, then, in our situation the presentation of a CS- directly prior to a non-feature trial would involve an expected event, whereas the presentation of a CS+ directly prior to a nonfeature trial would involve a surprising event.

We were also interested in investigating the effect of extending the delay between the preparatory interval and the onset of keylight illumination, since the results of our first experiment indicated that subjects in the FP group showed extremely good discriminative performance at 3-sec delay intervals. We wanted to determine how long a delay pigeons could successfully bridge in this situation as well as to find out whether the introduction of longer delays would re-establish a feature-positive superiority, after initial training with shorter delays had established comparable discriminative performance in both feature-positive and feature-negative conditions.

METHOD

Subjects

Sixteen female White Carneaux pigeons served, but two birds had to be discarded from the experiment for repeated failure to eat many of the USs. All subjects were housed and fed as in Experiment 1.

Apparatus

The apparatus was the same as in Experiment 1, except that four experimental chambers were used instead of two.

Procedure

All birds were given two consecutive days of magazine training, the procedure being identical to that followed in Experiment 1.

Phase 1: Red versus green discrimination training. The first phase of this experiment consisted of six days of training on a response-independent red versus green discrimination. Each session included 25 6-sec illuminations of the center key, separated by a variable intertrial interval averaging 60 sec (range = 30 to 90 sec). The first trial of every session was always positive, and all data from this trial were excluded from analysis. Of the remaining 24 key-light presentations, 12 were always followed immediately by 3 sec access to grain, and the other 12 were not.

For half the birds, all positive trials involved red key illuminations and all negative trials green key illuminations; for the other half, the colors were reversed. Henceforth, all red or green positive trials will be referred to as CS+, and all red or green negative trials as CS-.

Phase 2: Nondifferential training with pretrial USs. The second phase of this experiment consisted of six daily sessions which included 17 F and 16 \bar{F} trials, identical to those described in Experiment 1 (i.e., vertical lines appearing on left and right keys, etc.). During this phase, however, reinforcement was not preferentially correlated with either type of trial. Instead, a randomly selected half of both F and \bar{F} trials were followed by reinforcement for all subjects. The purpose of this nondifferential training was to determine the potential effects that pretrial reinforcement per se might have on pecking during subsequent key illuminations. A further modification of the procedure followed in Experiment 1 involved the use of two different delay intervals: half of both F and \bar{F} trials involved a 3-sec delay, as in Experiment 1, and the other half involved a 6-sec delay. During this phase, half of the 3-sec delay trials and half of the 6-sec delay trials were followed by reinforcement. As in Experiment 1, all trials were balanced for first-order sequential probabilities according to sequences given in Vandament et al. (1970). Data from the first trial of every session were excluded from analysis.

The red versus green discrimination was maintained during this phase by administering 17 CS+ and CS- trials on the center key in a block either before, after, or in the middle of the 33 F and \bar{F} trials. These massed red and green trials included an initial (positive) trial, followed by eight CS+ and eight CS- trials. All 50 trials of each daily session were sepa-

rated by a variable intertrial interval averaging 60 sec, as in Phase 1.

Phase 3: F versus \bar{F} discrimination training. After six days of nondifferential training, all subjects were matched for rate of key pecking to the vertical-line stimulus and assigned randomly by two's to either the FP ($n = 7$) or FN ($n = 7$) condition. This phase of the experiment was identical to the previous phase, except that F trials were consistently followed by reinforcement and \bar{F} trials consistently followed by no reinforcement in the FP group, whereas these contingencies were reversed in the FN group. The two different delay intervals were counterbalanced across F and \bar{F} trials. As before, the red versus green discrimination was maintained by administering a block of 17 trials at the beginning, middle, or end of each session. The F versus \bar{F} discrimination procedure was continued for 26 days.

Phase 4: Test. The next phase involved a test of short-term retention as a function of "surprising" and "expected" pretrial events. Half of both F and \bar{F} trials were directly preceded by CS+ and the other half by CS-. On every trial, either CS+ or CS- was presented on the center key, followed immediately by the clicking noise plus food or no food, the delay interval, and then left or right key illumination. The F and \bar{F} trials continued to be differentially associated with reinforcement, as in Phase 3. Thus, surprising events consisted of F trials preceded by CS- or \bar{F} trials preceded by CS+; expected events consisted of F trials preceded by CS+ or \bar{F} trials preceded by CS-. Eight of each of these types of trials (four at each of the two different delay intervals) were presented during each test session. Three such test sessions were each followed by four days of retraining on the F versus \bar{F} and red versus green discriminations, as in Phase 3. A standard block of red and green trials was administered at the beginning of each test session.

Phase 5: Delay gradient test. The final phase included more extensive variation of the delay interval. Initially, both groups of birds received 37 F and \bar{F} trials per day. As before, the first trial of every session was always positive, and the data from such trials were excluded from analysis. Of the remaining 36 trials, 12 were administered at either a 3-, 9-, or 27-sec delay (6 F and 6 \bar{F}), randomly interspersed throughout the session. After three days of training using these delay values, other delay

values were presented to different subgroups of birds. The specific procedures followed will be described with the results.

RESULTS

Phase 1: Red versus green discrimination training. Initial acquisition of the red versus green discrimination occurred very rapidly, and all subjects performed almost perfectly (98% to 100% of total key pecks to CS+) on the last day of Phase 1. With very few exceptions, no responding occurred to CS- throughout the 26 days of F versus \bar{F} discrimination training.

Phase 2: Nondifferential training with pre-trial USs. At no time during initial F versus \bar{F} training did the effect of delay interval (3 versus 6 sec) approach significance; therefore, all data have been collapsed across the two delay values. The left panel of Figure 4 shows the data from nondifferential training as the proportion of key pecking on F trials relative to responding on both F and \bar{F} trials. Data are

plotted separately for birds which were subsequently assigned to either the FP or FN condition, although all subjects were exposed to the same procedure during this phase. There was a very slight but consistent tendency to peck more on F than on \bar{F} trials. Although this tendency declined over training (the median proportion of pecking on F trials was .52 on the last day of nondifferential training), a t test for related measures performed on the mean rate of responding for all subjects on F versus \bar{F} trials on the last day of nondifferential training indicated that the effect was significant, $t(13) = 2.88$, $p < .02$.

The left panels of Figure 5 show the approach-withdrawal data from nondifferential training separately for subjects subsequently assigned to the FP (upper panel) or FN (lower panel) condition. Obviously, the proportion of time spent approaching the illuminated key did not differ as a function of F versus \bar{F} trials, $t(13) = 1.65$, $p > .10$, although both groups showed an increase in approach behavior on both types of trials during this phase.

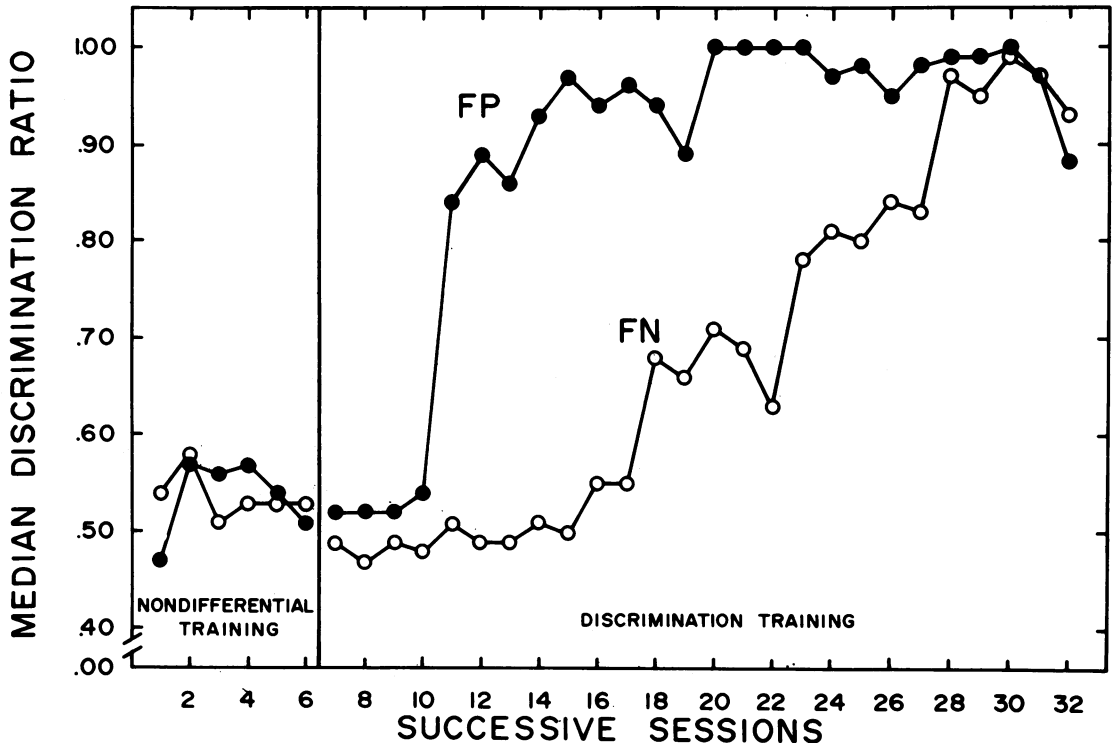


Fig. 4. Left panel shows proportion of key pecks on F trials relative to pecks on both F and \bar{F} trials during nondifferential training for subjects subsequently receiving FP or FN training in Experiment 2. Right panel shows proportion of pecking on positive trials relative to total pecks on all trials for FP and FN groups during discrimination training.

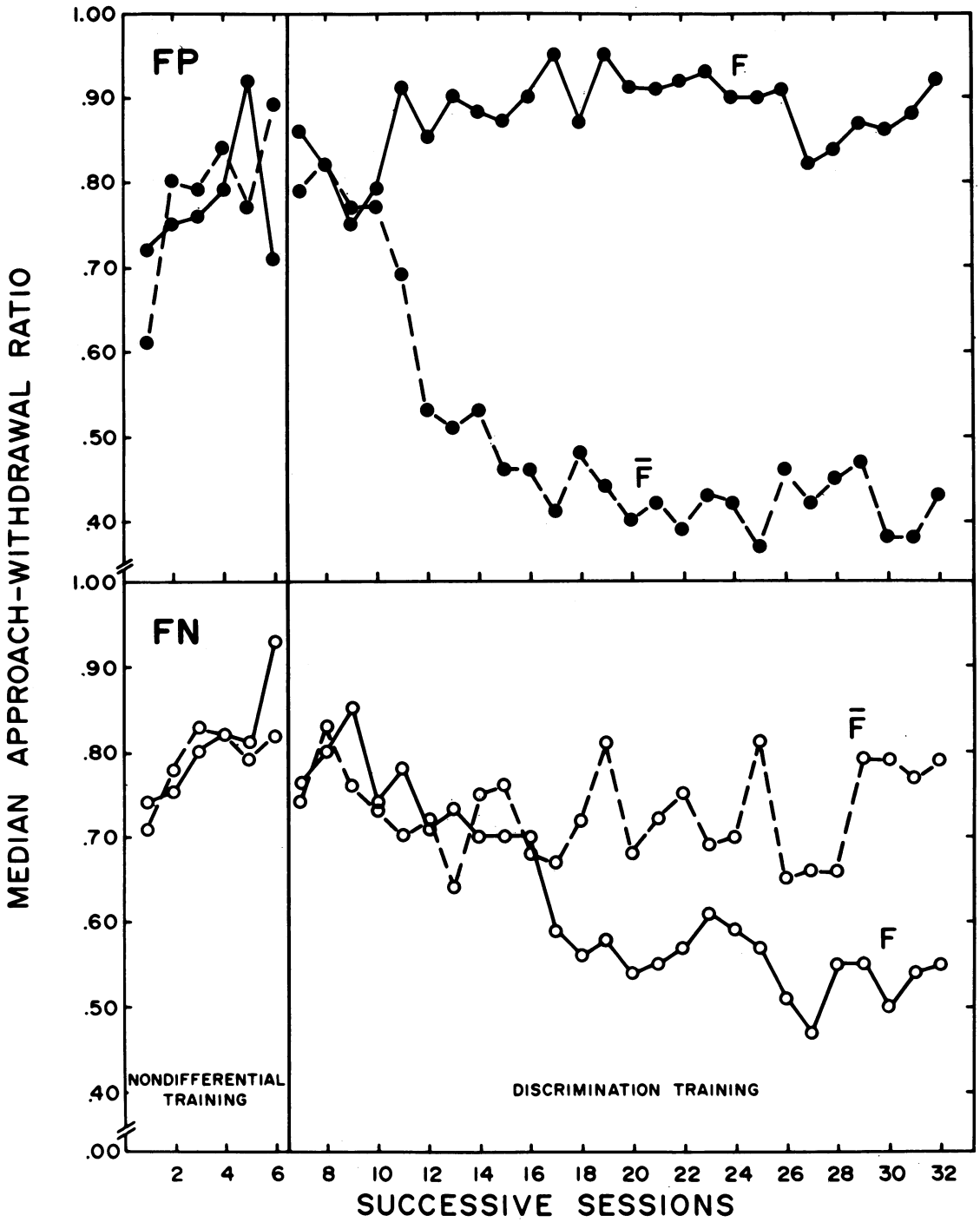


Fig. 5. Left panels show median approach-withdrawal ratios on F and \bar{F} trials during nondifferential training for subjects subsequently receiving FP (upper panel) or FN (lower panel) training in Experiment 2. Right panels show median approach-withdrawal ratios during discrimination training. See text for further explanation.

Phase 3: F versus \bar{F} discrimination training. The right panel of Figure 4 shows the development of the key-peck discrimination. These data are plotted as a proportion of responding on positive trials relative to responding on both positive and negative trials. The superiority of the FP group was even larger in this experiment than in the previous one. The mean number of days required to reach a discrimination ratio of .85 in a single session was 6.7 (range = 5 to 9) in the FP group, and 17.1 (range = 11 to 24) in the FN group, $t(12) = 4.75$, $p < .001$. However, the two groups reached equivalent levels of performance by the end of this phase.

The right panels of Figure 5 show the median approach-withdrawal ratios during F versus \bar{F} training. Again, the feature-positive superiority obtained here was even more striking than in the first experiment: whereas the FP group showed clear and consistent differentiation between F and \bar{F} trials beginning on the 5th day of discrimination training, the FN group did not show any such differentiation until about the 12th day of training. Furthermore, the FP group exhibited more approach on positive trials than did the FN group, and the former developed a tendency to withdraw from the illuminated key on negative trials. One subject in the FP group showed extremely clear-cut withdrawal behavior during negative trials, exhibiting an approach-withdrawal ratio of approximately .25 over the last several days of training.

As in Experiment 1, an approach-withdrawal difference score was obtained for each subject. Achievement of criterion was defined as a score greater than +.20 on three consecutive days of training. (One bird in the FN group exhibited pronounced freezing behavior after it had reached criterion for the key peck measure, and its data were eliminated from the experiment starting on Day 29, yielding an n of 6 in the FN group for the remainder of the experiment.) The mean number of days required to reach criterion was 8.3 (range = 4 to 22) in the FP group, and 20.5 (range = 11 to 26) in the FN group, $t(11) = 3.42$, $p < .01$. In addition, differential approach-withdrawal behavior exhibited by the FN group did not reach a level comparable to that exhibited by the FP group: A t test performed on the mean approach-withdrawal difference scores for Days 31 and 32

yielded a significant difference between the two groups, $t(11) = 3.08$, $p = .01$.

Phase 4: Test. Ratios of differences in key peck responding as a function of surprising versus expected trials were computed using data from the first test session. According to predictions, all subjects should have responded more on surprising positive trials than on expected positive trials, and should have responded less on surprising negative than on expected negative trials. Test performance ratios were calculated by using as the numerator the amount of responding on positive (or negative) trials on which a greater amount of responding was predicted to occur, and as the denominator the amount of responding on those same trials plus positive (or negative) trials on which a lesser amount of responding was predicted to occur. (This ratio was computed separately for positive and negative trials within each group.) A ratio of .50 indicates no change in responding as a function of surprising versus expected events, whereas ratios greater than .50 indicate performance changes in accordance with predictions. Except where noted below, there were no differences in performance as a function of delay interval (3 versus 6 sec).

If one considers the key-peck data first, the median test performance ratio during the first test session was .49 for positive trials and .43 for negative trials in the FP groups, and was .50 and .49 for positive and negative trials, respectively, in the FN group. If one considers next the approach-withdrawal data, the median test performance ratio was .52 and .46 for positive and negative trials, respectively, in the FP group, and was .48 and .43 for positive and negative trials, respectively, in the FN group. Thus, no trends in the predicted directions were obtained. In fact, there was a tendency for surprising negative trials to disrupt rather than facilitate performance in the FP group, as indicated by ratio values less than .50. Differential key peck responding as a function of surprising versus expected trials was assessed using Wilcoxon signed-ranks tests for related measures. Separate comparisons for positive and negative trials within each group were all nonsignificant, except for negative trials in the FP group, in which a higher rate of key pecking occurred during surprising than expected negative trials, $T = 1.0$, $p < .05$.

Analysis of the key peck data for the subsequent two test days yielded a similar pattern of results, with one exception: although FP subjects continued to respond more than usual on surprising negative trials ($T = 0.0$, $p = .02$), FN subjects began to show the effect implied by Terry and Wagner on negative trials, particularly at the 3-sec delay interval. Test performance ratios for negative trials at the 3-sec delay only were .60 and .84 on the second and third test days, respectively, with five out of six subjects responding less on surprising negative trials on both days. However, due to a rather large reversal shown by one subject, this effect failed to reach significance, $T = 5.0$, $p > .05$. No tendency was shown by either group to respond more on surprising positive trials than on expected positive trials.

The red versus green discrimination was not appreciably disrupted by the testing procedure: on the first two test days, median discrimination ratios in both groups were 1.0, and performance was only slightly worse on the third test day. However, the testing procedure did disrupt the F versus \bar{F} discrimination, particularly in the FP group, although performance improved progressively across the three test days. Median discrimination ratios were .56, .60, and .74 on the three test days, respectively, for the FP group, compared to a value of .88 on the day before the first test. Median discrimination ratios were .71, .71, and .83, respectively, for the FN group, compared to a value of .93 on the day before the first test.

Phase 5: Delay gradient test. Data from the first three days of F versus \bar{F} training with 3-, 9-, and 27-sec delay intervals are shown in Figure 6 for the FP (left panel) and FN (right panel) groups. All subjects in the FN group exhibited clear-cut gradients immediately, with performance levels deteriorating to chance at the 27-sec delay during the first two days. (The median discrimination ratio for FN subjects the day before delay gradient testing was .98.) By the third day, however, three of the six subjects began to demonstrate above-chance levels of performance even at the 27-sec delay (exhibiting discrimination ratios of .64, .69, and .74, respectively). Data from the FP subjects showed quite a different story: performance was completely disrupted after only one day of training with extended delay intervals. Even on the first day, performance at the 3-sec delay dropped to a median level of .79, compared to

.94 the day before. By the third day of training, median performance at the 3-sec delay had dropped to .57 (range = .46 to .65). An analysis of variance including Delay Interval as a repeated measure yielded a significant effect of Type of Discrimination [$F(1, 11) = 14.13$, $p < .005$], Delay Interval [$F(2, 22) = 24.02$, $p < .001$], and their interaction [$F(2, 22) = 19.85$, $p < .001$].

In an effort to determine whether long-delay discriminative performance in FP subjects could be improved, different subgroups of birds in the FP group received slightly different treatments. Four subjects whose performance had completely deteriorated were retrained for four days with 3- and 6-sec delays; they then received two days of training with 3-, 9-, and 15-sec delay intervals, and finally three days of training with 3-, 9-, and 27-sec delays. (One bird from this subgroup was dropped from the experiment because it never recovered above-chance performance levels.) A second group of four FP subjects whose overall discrimination ratios were still above chance after the three initial days of delay gradient testing received an additional nine days of training with 3-, 9-, and 27-sec delay intervals, exactly as before.

Neither the "titration" procedure administered to the first subgroup of birds nor the extended training administered to the second subgroup of birds was effective in producing clear-cut gradients similar to those displayed by individual FN subjects. Although some birds showed sporadic evidence of decreasing performance with longer delays, there existed a strong tendency to perform at intermediate, equivalent (i.e., .60) levels over all delays.

After the first three days of delay gradient testing, subjects in the FN group received an additional five days of continued training with the 3-, 9-, and 27-sec delays. During this time, median discrimination ratios remained consistently around .75, and performance was perfect at the two shorter delays. Therefore, these subjects were given three days of training with 3-, 12-, and 48-sec delay intervals; relevant data are shown in Figure 7. Performance decreased to chance levels on trials with the 48-sec delay and showed no tendency toward improvement over three days of training. However, performance was virtually perfect at the 12-sec delay by the third day of training.

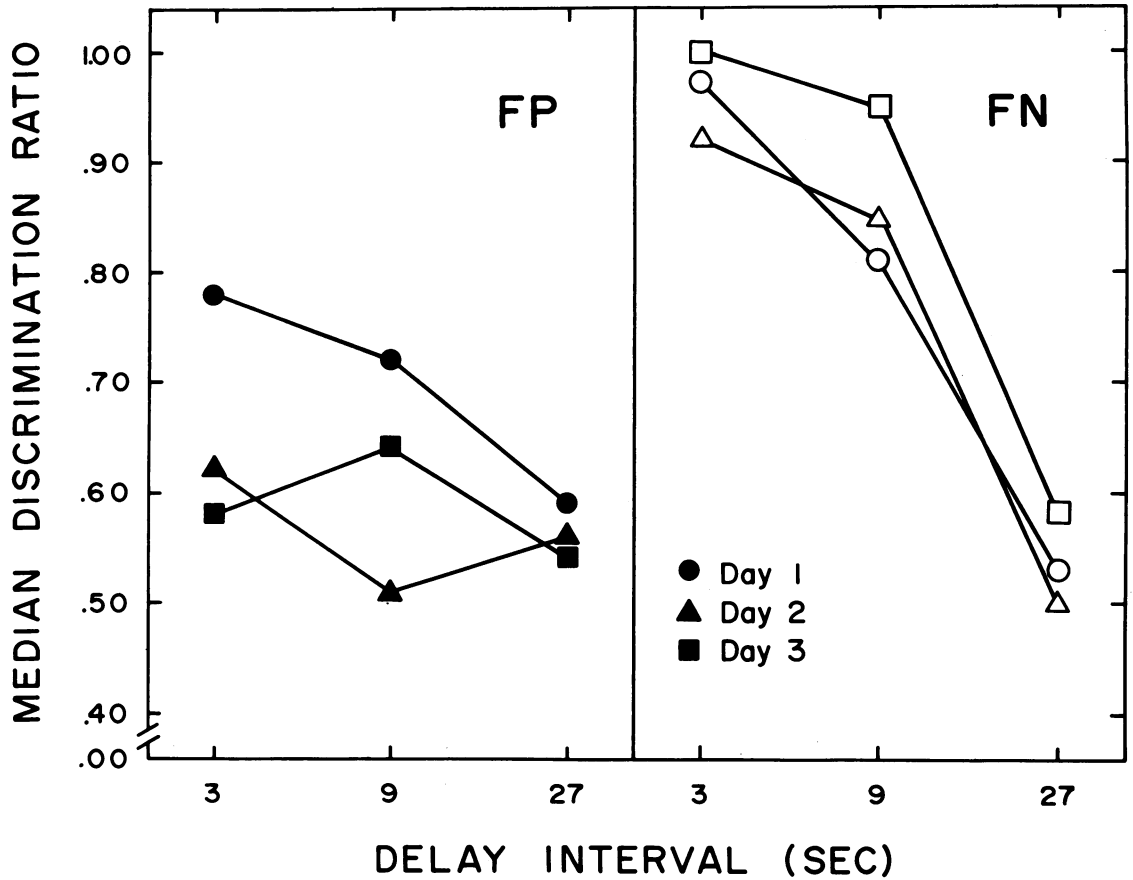


Fig. 6. Median key peck discrimination ratios for FP (left panel) and FN (right panel) groups of Experiment 2 as a function of delay interval duration. Data are plotted separately for the first three days of training with 3-, 9-, and 27-sec delays.

DISCUSSION

The results of Experiment 2 provided further support for the findings of Experiment 1. Although in Experiment 2 subjects exhibited a tendency to respond slightly more on F than on \bar{F} trials during nondifferential training, it seems unlikely that this slight difference could account for the rapid improvement shown by the FP group after the first few days of differential training. Furthermore, a robust feature-positive effect was obtained in terms of the approach-withdrawal measure, even though this measure revealed no tendency toward greater approach on F than on \bar{F} trials during nondifferential training.

Our failure to replicate the pattern of results reported by Terry and Wagner (1975) for differential short-term retention of surprising and

expected events may be attributable to several factors. The failure to obtain superior performance on surprising positive trials could well be due to a ceiling effect—that is, since subjects were pecking at a very high rate on all positive trials, they could not significantly increase their rate of responding. Performance on negative trials, however, was definitely not subject to a floor effect. Subjects in the FN group did make fewer responses (i.e., fewer errors) on surprising than on expected negative trials on the second two test days, in accordance with predictions. However, subjects in the FP group exhibited a significant trend in the opposite direction: many more responses (i.e., more errors) were made on surprising than on expected negative trials. Furthermore, this effect became more pronounced with repeated testing: on the third test day, FP subjects made an average

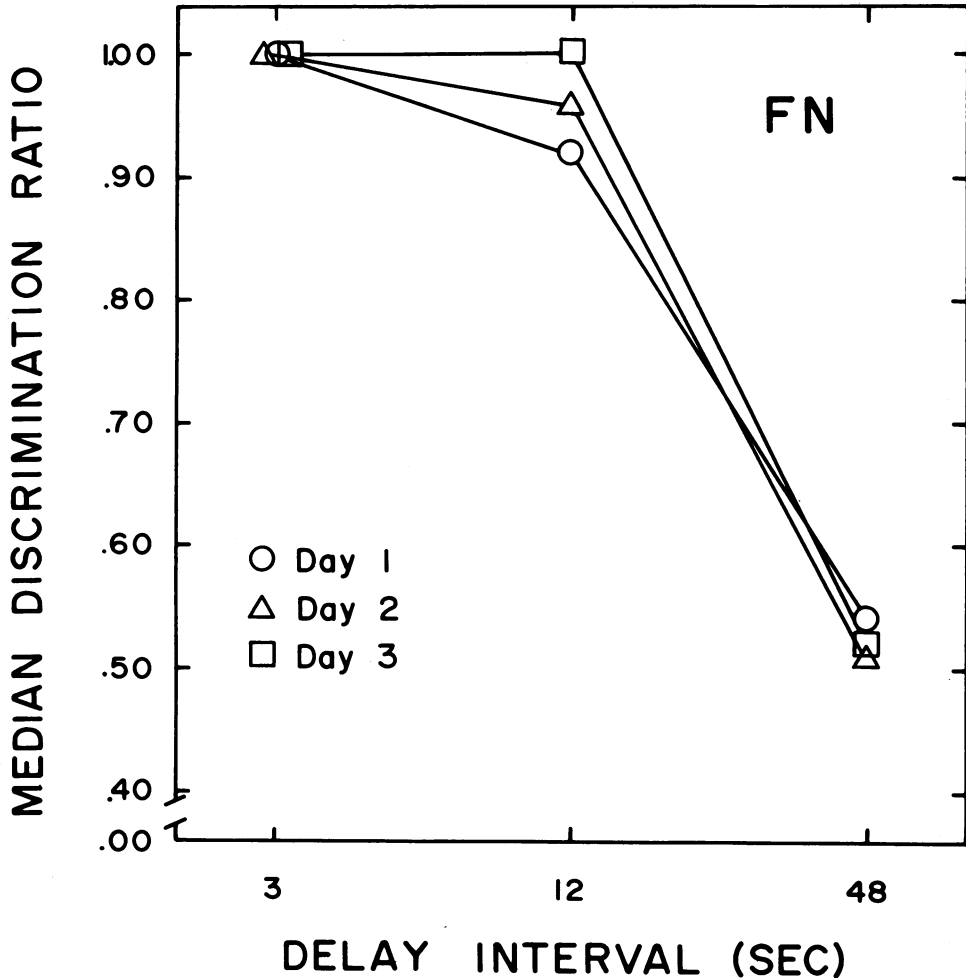


Fig. 7. Median key peck discrimination ratios for FN subjects of Experiment 2. Data are plotted separately for three days of training with 3-, 12-, and 48-sec delays.

of 3.16 responses on expected negative trials and 12.43 responses on surprising negative trials (yielding a test performance ratio of .20).

An alternative way of conceptualizing the results of the surprise test for both FP and FN subjects may be summarized as follows: during test sessions, *both* FP and FN subjects responded more when CS+ directly preceded a negative trial (i.e., a \bar{F} or a F trial for FP and FN, respectively). When negative trials were directly preceded by CS-, many fewer errors were made in both groups. It so happened that behavior on "expected" trials was thus disrupted in the FN condition, whereas behavior on "surprising" trials was disrupted in the FP condition. As compared to the "surprise" explanation, the pattern of responding we obtained on negative trials may be more parsimoniously

attributed to a higher rate of responding engendered by close temporal proximity of positive (CS+) trials from the red versus green discrimination with negative trials from the F versus \bar{F} discrimination. Such an outcome may be related to so-called transfer experiments (e.g., Hearst & Peterson, 1973; Rescorla & Solomon, 1967) in which, for instance, the presentation of a CS+ may raise the baseline level of an independently established operant response. In the present case, a temporally contiguous CS+ may act to increase responding over the "baseline" level established to negative trials of the F versus \bar{F} discrimination.

Though the reasons for the discrepancy between our findings and those of Terry and Wagner are not altogether clear, numerous dif-

ferences between the two studies may be relevant. For example, our pretrial US was always accompanied by a clicker and was thus distinguishable from posttrial USs, which were always presented alone (during red versus green discrimination training as well as F versus \bar{F} training). In addition, our test procedure appeared to generate a considerable amount of proactive interference (unlike the one employed by Terry and Wagner), since overall F versus \bar{F} performance on test days was considerably lower than on regular training days. Finally, the obvious fact that, unlike Terry and Wagner, we were attempting to manipulate some representation of "US" as opposed to "US" may account for our failure to observe superior retention of an unexpected episode.

However, in reference to this last point, it may be noted that one test procedure employed by Terry and Wagner could be regarded as manipulation of a "US" representation. During one "surprise" test, they compared performance on trials in which the pretrial US was directly preceded by CS+ or CS- with performance on trials in which CS+ and CS- were substituted for the pretrial US. Inspection of their Figure 6 suggests that on these latter two types of trials, which are similar to our surprising and expected nonfeature trials, respectively, Terry and Wagner also obtained evidence inconsistent with their general predictions—i.e., performance was worse on surprising (CS+ \rightarrow \bar{US}) than on expected (CS- \rightarrow \bar{US}) trials. However, it is likely that Terry and Wagner's subjects treated these latter types of test trials as a substitute for the pre-trial event (as did Terry and Wagner, incidentally), since all other trials included no pretrial event at all and were not subjected to any manipulations but were presented during test sessions as in regular training sessions. In this case, it is difficult to know exactly how to interpret the results of Terry and Wagner's test trials in which CS+ and CS- were presented as pretrial events.

To make matters even more complicated, Maki (in press), using pigeons in a delayed matching-to-sample paradigm, tested retention of surprising versus expected " \bar{US} " representations and found significantly better short-term retention on trials when the absence of food was unexpected, as Terry and Wagner's analysis would seem to predict. Better performance was also obtained when food presentations were surprising rather than expected, but in all

cases, the effect developed only slowly with repeated testing, an outcome which is clearly incompatible with the simple notion that surprising events directly promote rehearsal.

Obviously, further research is necessary in order to reconcile these discrepant findings.

The results of variations in the delay interval were surprising to us. Our original expectation was that lengthening the delay between the preparatory interval and key illumination would reinstate the superior performance initially demonstrated by the FP group. Contrary to our expectations, however, the opposite effect was obtained. Whereas lengthening the delay interval produced decreasing gradients in FN subjects with performance at short delays being maintained at high levels, lengthening the delay interval produced general disruption of performance even at short delays in FP subjects.

The disruption of performance caused by extended delay intervals in the FP condition could be attributable to several factors, but one possibility seemed particularly plausible to us. Throughout F versus \bar{F} training, FP subjects had been consistently exposed to a US-US interval of either 9 or 12 sec (for the 3- and 6-sec delays, respectively). In addition, the average time (comprising one or more intertrial intervals) between these US-US pairings was considerably longer in comparison, ranging from 30 to approximately 180 sec. In contrast, US presentations were always isolated in the FN condition. Since one US was presented per trial in this condition, the average interval between USs was 60 sec (30 to 90 sec). Thus, it seemed possible that subjects in the FP condition could have been learning to discriminate the temporal interval between USs from other aspects of the experimental treatment. Speaking casually, perhaps the US-US interval in the FP condition was engendering some sort of Gestalt perceptual organization (see Jenkins, 1970) based on similarity (in this case, identity) and temporal proximity. When this relationship was disrupted by lengthening the US-US interval, performance deteriorated.

This hypothesis naturally suggested the possibility that the identity of feature and reinforcement in our procedure was mainly or partially responsible for the obtained feature-positive superiority. That is, perhaps the development of some sort of "perceptual organization" induced by the US-US interval in the FP

condition was the underlying mechanism whereby FP subjects demonstrated faster learning than FN subjects. Our next experiment was designed to test this notion.

EXPERIMENT 3

In this experiment, all subjects were exposed to both an FP and an FN contingency. Each subject received exposure to four different types of trials. The first two types of trials were identical to those of the FP condition in Experiments 1 and 2; the second two types of trials were identical to those of the previous FN condition, except that a white horizontal line on a black background was presented in place of the vertical white line. Thus, all subjects had to form a conditional discrimination based on the presence or absence of a pretrial food delivery in conjunction with a particular keylight stimulus. In this arrangement, the presentation of a pretrial food delivery was followed by reinforcement only 50% of the time (as was the absence of a pretrial food delivery). Thus, if a within-subject feature-positive superiority could be obtained using this procedure, then the presence of a unique US-US interval in our previous FP treatments could not be responsible for the obtained feature-positive superiority. Finally, after all subjects had reached asymptotic discriminative performance, the delay interval was varied in order to determine whether or not the differential effects of delay interval on FP versus FN performance that were exhibited during Experiment 2 would obtain in the present within-subject design.

METHOD

Subjects

Eight female White Carneaux pigeons served, but one bird became ill and had to be eliminated from the experiment. They were housed and fed as in Experiments 1 and 2.

Apparatus

The apparatus was the same as in Experiment 2.

Procedure

All birds were given two consecutive days of magazine training, exactly as in Experiments 1 and 2.

Phase 1: Nondifferential training with pre-

trial USs. During this phase of the experiment, all subjects were exposed to eight different types of trials during each session. As in previous experiments, half of these were F trials and half were \bar{F} trials. However, in this case, half of both F and \bar{F} trials involved the presentation of a vertical white line on a black background, and the other half involved the presentation of a horizontal white line on a black background. All keylight stimuli were presented on the left-hand key (i.e., only one key was used in this experiment). In addition, each type of trial was followed by reinforcement and nonreinforcement equally often, so that feature-vertical line, feature-horizontal line, nonfeature-vertical line, and nonfeature-horizontal line trials were each followed by reinforcement on half of the occasions that they were presented. The duration of the delay interval was 3 sec on all trials, which were balanced for first-order sequential probabilities as in Experiments 1 and 2.

All sessions included the presentation of 48 trials (6 of each of the 8 trial types) separated by a variable intertrial interval averaging 60 sec (range = 30 to 90 sec). Nondifferential training was continued for six sessions.

Phase 2: Discrimination training. This phase of the experiment was identical to the previous one except that reinforcement always followed two different trial types and never followed two other different trial types. Thus, all subjects were exposed to four types of trials: Feature-reinforced (F+), nonfeature-nonreinforced (\bar{F} -), nonfeature-reinforced (\bar{F} +) and feature-nonreinforced (F-). The first two types of trials constituted the positive and negative signals, respectively, of a feature-positive discrimination; the second two types of trials constituted the positive and negative signals, respectively, of a feature-negative discrimination. For three subjects, the vertical-line stimulus was always presented on trials involving the FP discrimination. That is, the vertical-line stimulus was always followed by reinforcement when it was preceded by a pretrial food delivery (F+) and was never followed by reinforcement when it was preceded by the clicker stimulus alone (\bar{F} -). For these same subjects, the horizontal-line stimulus was always presented on trials involving the FN discrimination. Thus, the horizontal-line stimulus was always followed by reinforcement when preceded by the clicker stimulus alone (\bar{F} +) and was never followed by

reinforcement when preceded by a pre-trial food delivery (F—). For the four remaining subjects, the roles of the vertical-line and horizontal-line stimuli were reversed. The four types of trials presented to all subjects are identical to those diagrammed in Figure 1.

All sessions included the presentation of 12 of each of the 4 trial types, yielding a total of 48 trials. Discrimination training was continued for 25 sessions.

Phase 3: Delay gradient testing. This phase of the experiment was identical to the previous one, except that half of each of the four types of trials presented involved a 3-sec delay, as in previous training, and the other half involved a longer delay. The longer delay was 9 sec for the first six days of delay gradient testing, and was then increased to 15 sec for an additional eight days of testing.

RESULTS

Phase 1: Nondifferential training with pre-trial USs. Key-peck data from this phase of the experiment will not be presented because acquisition of pecking was slow in this experiment: the mean number of sessions until the first peck was made was 3 (range = 1 to 5), and most birds did not reach an asymptotic rate of responding until the last day of nondifferential training or thereafter. During the last day of nondifferential training, the median proportion of responses which occurred on F trials involving the horizontal line (relative to responses made on both F and \bar{F} trials) was .52, and the median proportion of responses which occurred on F trials involving the vertical line was .54. Thus, as in Experiment 2, a small bias in favor of greater responding on F trials was obtained. A within-subject analysis of variance yielded a significant effect only for this difference in responding between F and \bar{F} trials, $F(1, 6) = 12.78, p < .025$. The effect of horizontal-line versus vertical-line stimuli did not approach significance [$F(1, 6) = 1.76, p > .20$], nor did the interaction of the two factors ($F < 1$).

The approach-withdrawal data are shown in the left panel of Figure 9. (The data are plotted in terms of subsequent experimental treatment and are, therefore, collapsed across the two different keylight stimuli.) There was a tendency for more approach to occur to the illuminated key on F trials than on \bar{F} trials, regardless of whether the vertical-line or hori-

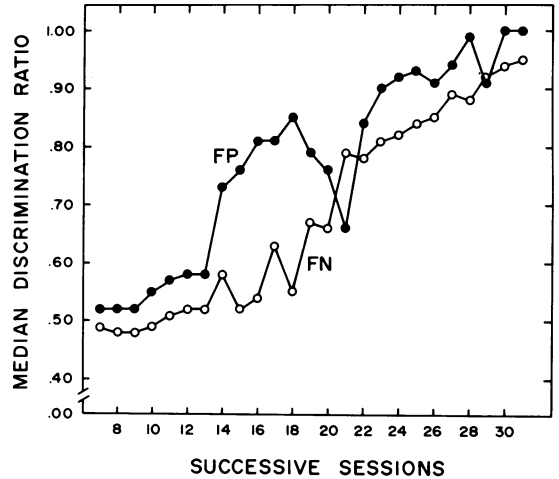


Fig. 8. Median key peck discrimination ratios for subjects of Experiment 3. Data are plotted separately for FP and FN discriminations. See text for further explanation.

zontal-line stimulus was present. A within-subject analysis of variance performed on the data from the last day of nondifferential training yielded a significant effect of F versus \bar{F} trials [$F(1, 6) = 15.33, p < .01$] but not of horizontal-versus vertical-line stimuli [$F(1, 6) = 1.93, p > .20$] nor of their interaction ($F < 1$).

Phase 2: Discrimination training. The key-peck data from this phase are shown in Figure 8. Clear evidence for a within-subject feature-positive effect was obtained: All seven subjects exhibited a discrimination ratio of .85 in a single session for the FP discrimination before reaching the same level for the FN discrimination. The number of days required to reach this criterion for the FP discrimination was subtracted from the number of days required to reach the same criterion for the FN discrimination for each subject: The mean value of this difference score was +6.1 (range = +3 to +11). Thus, at least three days elapsed in individual subjects between reaching criterion for the FP discrimination and reaching it for the FN discrimination. A within-subject analysis of variance revealed that this effect was highly significant, $F(1, 6) = 28.89, p < .005$.

There was some tendency for subjects to show a decrease in performance on the FP discrimination after having reached the .85 level, as indicated by the overall drop in performance evident in Figure 8. However, they improved again immediately, and performance on the FP discrimination was slightly though

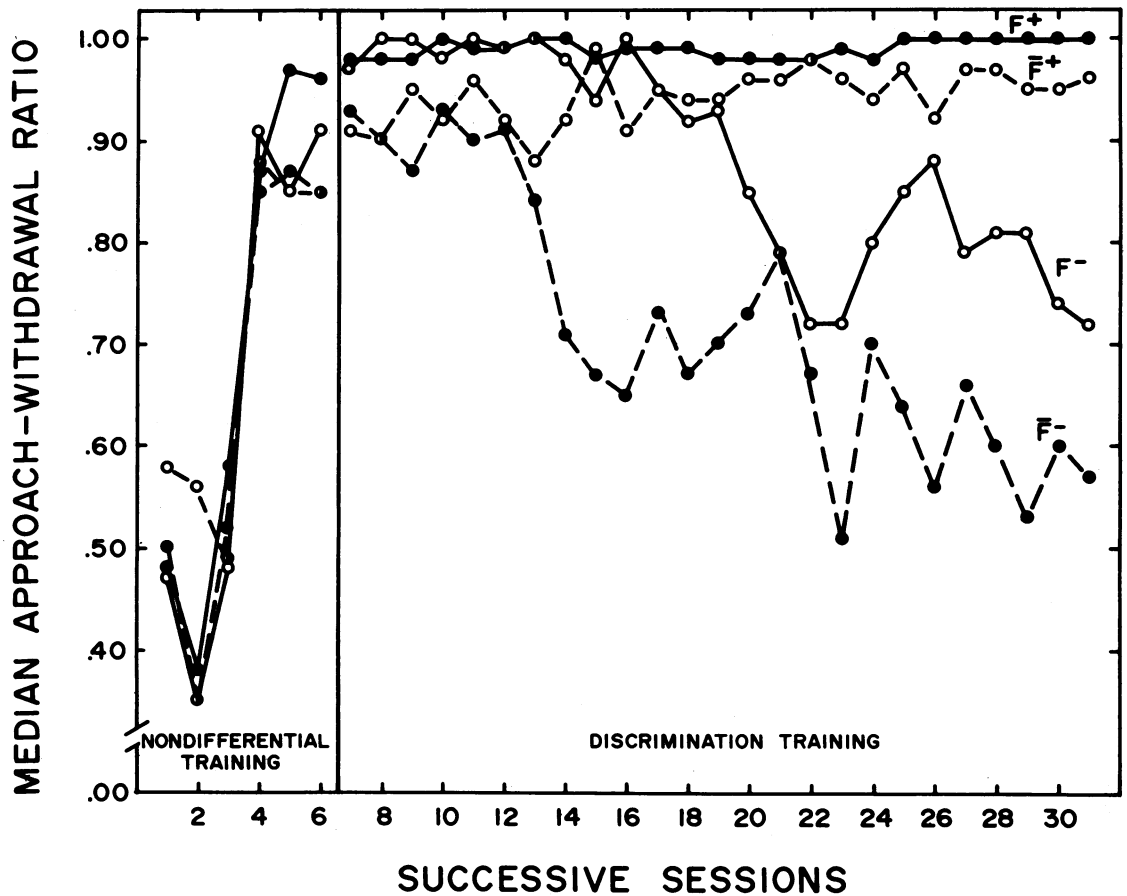


Fig. 9. Left panel shows median approach-withdrawal ratios during nondifferential training for subjects of Experiment 3; data are plotted separately as a function of subsequent experimental treatment. Right panel shows data from discrimination training: F+ = feature-reinforced trials; F- = nonfeature-nonreinforced trials; F+ = nonfeature-reinforced trials; F- = feature-nonreinforced trials. See text for further explanation.

consistently better than performance on the FN discrimination over the last several days of training.

The right panel of Figure 9 shows the median proportion of approach behavior to the illuminated key during discrimination training for each of the four types of trials. Clear differentiation between positive (F+) and negative (F-) trials was obtained for the FP discrimination after the first several days of training, whereas differentiation between positive (F+) and negative (F-) trials on the FN discrimination did not develop until much later, and never reached a level comparable to that obtained under the FP discrimination.

The amount of approach behavior obtained on positive trials was subtracted from that obtained on negative trials for each subject under

both the FP and FN discriminations. A performance criterion was defined as a score greater than +.20 on three consecutive days. If this criterion was never met, the maximum value of 25 days was assigned. The mean number of days required to reach criterion was 11.3 (range = 3 to 25) on the FP discrimination and 19.7 (range = 6 to 25) on the FN discrimination, $F(1, 6) = 11.49$, $p < .025$. Only one subject failed to reach criterion on the FP discrimination, whereas four out of the seven subjects failed to reach criterion on the FN discrimination.

Phase 3: Delay gradient testing. The pattern of results obtained during delay gradient testing was similar to the pattern of results obtained in Experiment 2, as shown in Figure 10. The introduction of longer delays yielded or-

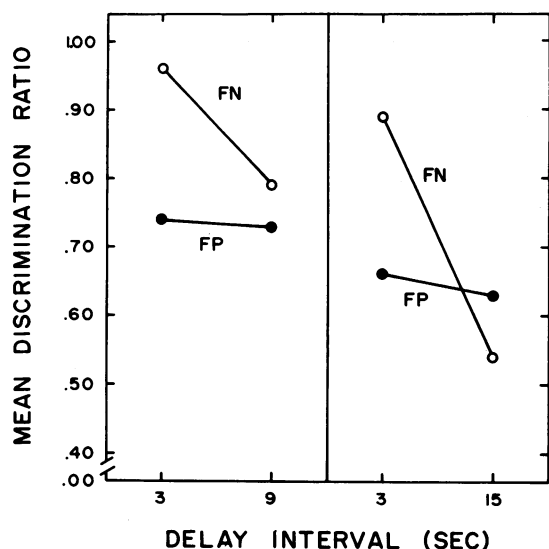


Fig. 10. Mean key peck discrimination ratios for subjects of Experiment 3 during delay gradient testing. Data are plotted separately for FP and FN discriminations. Left panel shows data averaged over Days 5-6 of training with 3- and 9-sec delays. Right panel shows data averaged over Days 7-8 of training with 3- and 15-sec delays.

derly gradients for the FN discrimination: performance was maintained at high levels by all subjects at the 3-sec delay but dropped off to intermediate levels at the 9-sec delay (left panel) and chance levels at the 15-sec delay (right panel). The introduction of longer delays decremented performance under the FP discrimination at *both* the short and long delays. As in Experiment 2, there was a tendency for subjects to perform at equivalent intermediate levels of performance at both delays under the FP discrimination. The right panel of Figure 10 indicates that subjects performed better on the FP discrimination than on the FN discrimination at the 15-sec delay, and the opposite was true at the 3-sec delay. A within-subject analysis of variance indicated that the main effect of Delay Interval (3 versus 15 sec) was highly significant [$F(1, 6) = 130.00, p < .001$], and the main effect of Type of Discrimination was marginally significant [$F(1, 6) = 5.79, p > .05$]. The interaction of the two factors was also significant, $F(1, 6) = 49.83, p < .001$. Individual t tests for related measures indicated that FP versus FN performance was reliably different at both the 3-sec delay [$t(6) = 35.10, p < .001$] and the 15-sec delay [$t(6) = 25.51, p < .001$].

DISCUSSION

The results of the present experiment indicate quite clearly that the feature-positive superiority obtained in Experiments 1 and 2 cannot be attributed to the short and relatively regular US-US interval that was a unique aspect of the FP condition in those between-group studies. A clear-cut feature-positive effect was obtained within individual subjects in Experiment 3, even though pretrial US presentations were followed by another US on only half the occasions that they were presented. Furthermore, pretrial US presentations themselves were not predictive of whether or not reinforcement was forthcoming, thus eliminating the potential discriminative effects of the US-US interval itself as an explanation of superior performance by FP subjects in Experiments 1 and 2.

The present experiment also bears on a theoretical issue of some importance concerning the feature-positive effect. It has been suggested (e.g., Jenkins & Sainsbury, 1970; Sainsbury, 1971, 1973) that the inferior performance obtained under a feature-negative discrimination may be attributable to the fact that FN subjects must acquire a conditional discrimination of the form: respond to common element if feature is absent; don't respond to common element if feature is present. Feature-positive subjects, on the other hand, may only have to acquire a simple feature-present versus feature-absent discrimination. Results of the present experiment argue against such a general explanation of the feature-positive effect. The design utilized here obviously necessitated the formation of a conditional discrimination for both the FP and FN discriminations, since neither feature presence nor feature absence per se provided sufficient information to solve either discrimination problem. In spite of this fact, however, every subject acquired the FP discrimination before the FN.

As in Experiment 2, a slight initial bias in terms of greater responding on feature trials was obtained. However, there was no evidence that performance during nondifferential training or the first few days of discrimination training was correlated with how rapidly discriminative performance was acquired. In fact, one subject made relatively more key peck responses on positive ($F+$) trials of the FN discrimination than on positive ($F+$) trials of the

FP discrimination over the first few days of discrimination training, but ultimately required 12 days to reach criterion on the FP discrimination and 17 days to reach criterion on the FN discrimination.

GENERAL DISCUSSION

Our studies indicated that, as has been shown in other situations (see Hearst, 1978), the presence of a unique cue correlated with subsequent reinforcement produced better discriminative performance than did the presence of that same cue correlated with the absence of reinforcement. A feature-positive superiority was obtained in all three of the experiments reported here, which included between-subject (Experiments 1 and 2) as well as within-subject (Experiment 3) demonstrations. The results of Experiments 1 and 2 testified to the reliability of the feature-positive superiority obtained in our situation. This was particularly well illustrated by the key-peck data of Experiment 2, in which two days elapsed between *all* of the FP subjects reaching criterion and the *first* FN subject reaching criterion. Experiment 3 indicated that faster learning in the FP condition could not be attributed to the fact that positive trials included two US presentations and negative trials none, whereas positive and negative trials each included one US presentation in the FN condition. Furthermore, that an FP superiority was obtained in Experiment 3, even though the design necessitated the formation of a complex conditional discrimination, indicated that the effect was not due to the fact that the FN condition required formation of a conditional discrimination whereas the feature-positive discrimination did not.

The results of these experiments are, in addition, consistent with those of a number of recent studies which indicate that an appetitive US can serve as an effective signal even if it is no longer present when differential performance is measured. Thus, it may be more accurate to say that some internal trace or representation of a US may serve as a cue or may acquire signal value. Short-term retention of appetitive USs has been demonstrated within the delayed matching-to-sample paradigm (Maki, in press; Maki, Moe, & Bierley, 1977; Wilkie, 1978). A slightly different class of studies (e.g., Capaldi, 1971; see also Heise, 1975,

who utilized a procedure very similar to our feature-negative condition) have investigated the ability of animals to use the outcome of one trial as a cue to predict the next, and have found that animals can retain the outcome of a previous trial (i.e., reinforcement or nonreinforcement) for several minutes (see Mackintosh, 1974). A number of experiments which are also concerned with short-term retention of appetitive USs have compared memory for food delivery versus memory for a brief stimulus presentation at the completion of a fixed-interval schedule requirement (see Staddon, 1974).

The ability of (FN) pigeons to exhibit good discriminative performance at extremely long delays (e.g., 12 to 27 sec) was quite surprising to us. This outcome is, however, consistent with results reported by Honig (1978) and Wilkie (1978), both of whom found that pigeons evidenced high levels of performance at delays ranging from 20 to 30 seconds.

Although the differential results for FP and FN conditions obtained by extending the delay gradient in Experiments 2 and 3 are intriguing, the mechanism responsible for them is not immediately obvious. When short and long delays were intermixed within a session, an interaction between the length of the delay and the type of discrimination in effect was obtained which indicated that FP performance was inferior to FN performance at short delays but was, if anything, superior at long delays (as in the right panel of Figure 10). This outcome was due to a differential decrease in suppression of responding on negative trials. That is, pecking on positive trials, both F and \bar{F} , was maintained at high levels in both groups during all delay conditions. Pecking was maintained at very low levels on negative trials, both F and \bar{F} , during baseline when all delays were 3 sec long; but, although pecking still occurred infrequently on negative F trials (FN condition) at short delays during delay gradient testing, when longer delays were intermixed, responding was *not* similarly suppressed on negative \bar{F} trials (FP condition). Our original supposition that this disruption of performance was caused by lengthening the US-US intervals in the FP condition, thereby removing the temporal relation necessary for some organizational process, cannot account for the results of Experiment 3. As of yet, we have no satisfactory interpretation of this outcome and

can only hope that further research will help to elucidate it.

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